TITLE OF THE INVENTION

DRUM WASHING MACHINE AND METHOD OF CONTROLLING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Patent Application No. 2003-54709, filed August 7, 2003 in the Korean Intellectual Property Office, the disclosures of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a drum washing machine and method of controlling the drum washing machine, which is provided with a rotary drum having an improved structure, thus washing laundry using a small amount of wash water.

2. Description of the Related Art

[0003] A drum washing machine is an apparatus in which a driving force of a motor rotates a rotary drum so that laundry is washed while the laundry soaked with wash water and detergent is raised and dropped in the rotary drum.

[0004] A conventional drum washing machine generally includes a water tub to contain wash water used in a washing process, and a rotary drum located in the water tub to be rotated and which is provided with a plurality of perforations therein to allow the wash water to flow thereinto.

[0005] The conventional drum washing machine is supplied with the wash water not only to fill a space between an inner surface of the water tub and an outer surface of the rotary drum, but also to immerse the laundry contained in the rotary drum.

[0006] The conventional drum washing machine is disadvantageous in that an amount of wash water used is excessive because the wash water supplied to the water tub flows into the rotary drum after filling the water tub from a bottom of the water tub, thus immersing laundry.

[0007] Furthermore, the conventional drum washing machine is problematic in that an excessive time not only is required at a time of supplying and draining the wash water because excessive wash water is used in washing, but also excess electric energy is used in a process of heating excessive wash water using an electric heater.

SUMMARY OF THE INVENTION

[0008] Accordingly, it is an aspect of the present invention to provide a drum washing machine and method of controlling the drum washing machine, in which a drain structure of a rotary drum is improved, thus reducing an amount of wash water used, conserving electric energy, and reducing overall washing time.

[0009] The above and/or other aspects are achieved by providing a drum washing machine, including a water tub to contain wash water used in a washing process, a rotary drum located in the water tub to contain the wash water, a first water supply unit to supply the wash water into the water tub, a second water supply unit to supply the wash water into the rotary drum, and a controller to control the first and second water supply units to supply the wash water into the water tub and the rotary drum, respectively, while washing laundry, which has been placed in the rotary drum.

[0010] The drum washing machine may further include a drum driver to rotate the rotary drum, and a circulator to supply the wash water contained in the water tub into the rotary drum.

[0011] The controller may control the drum driver and the circulator to mix the wash water contained in the water tub with the wash water contained in the rotary drum and to utilize the mixed wash water.

[0012] The controller may control the drum driver to wash laundry using only the wash water supplied into the rotary drum.

[0013] The rotary drum may be positioned to be inclined to contain the wash water while being stopped, and may be provided with a plurality of perforations to drain the contained wash water while being rotated.

[0014] The perforations may be formed along a radially outer portion of a front wall of the rotary drum.

[0015] The drum washing machine may further include a heater to heat the wash water contained in the water tub, and the controller may control the heater to heat the contained wash water and may control the circulator to supply the heated wash water to the rotary drum.

[0016] The heater may be an electric heater controlled by the controller.

[0017] The drum washing machine may further include a water temperature sensor to detect temperature of the wash water contained in the water tub, and the controller may control the heater to heat the contained wash water in stages until the water temperature detected by the water temperature sensor reaches a set temperature.

[0018] The drum washing machine may further include a washing course setting unit to set a washing course of the laundry, and the controller may determine the set temperature corresponding to the washing course set by the washing course setting unit.

[0019] The drum washing machine may further include a storage unit to store information about the set temperature corresponding to the washing course, and the controller may recognize the set temperature by searching the storage unit.

[0020] The above and/or other aspects are achieved by providing a method of controlling a drum washing machine, the drum washing machine having a water tub to contain wash water and a rotary drum located in the water tub to contain the wash water while being stopped and to drain the contained water while the washing machine is rotated, including producing detergent solution by putting the wash water and detergent into the water tub, and performing main washing operation to wash laundry which has been placed in the rotary drum using the produced detergent solution and the wash water contained in the rotary drum.

[0021] The method may further include performing a rough washing operation to soak the laundry by supplying the wash water into the rotary drum and operating the rotary drum prior to the main washing.

[0022] The method may further include mixing the wash water used in the rough washing operation with the wash water contained in the water tub by draining the wash water, which is used in the rough washing operation, from the rotary drum, and supplying the mixed wash water into the rotary drum to be used in the main washing operation.

[0023] The method may further include heating the mixed wash water by operating an electric heater.

[0024] The heating of the mixed water may include detecting temperature of the heated wash water, and heating the heated wash water in stages until the heated wash water reaches a set temperature.

[0025] The method may further comprise performing a preliminary washing operation by rotating the rotary drum while heating the mixed water in stages, and the main washing operation may be performed after the preliminary washing operation has been performed.

[0026] Additional and/or other aspects and advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a view illustrating an internal structure of a drum washing machine, according to an embodiment of the present invention;

FIG. 2A is a view illustrating a state in which wash water is drained by rotating a rotary drum at high speed, according to the present invention;

FIG. 2B is a view illustrating a state in which the wash water is sprayed into the rotary drum, according to the present invention;

FIG. 3 is a perspective view illustrating the rotary drum of the drum washing machine of FIG. 1;

FIG. 4 is a sectional view of the rotary drum of FIG. 3;

FIG. 5 is a block diagram of the drum washing machine of FIG. 1;

FIG. 6 is a flowchart illustrating a method of controlling the drum washing machine of FIG. 1; and

FIG. 7 is a graph showing variations of water temperature while the drum washing machine performs washing.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0028] Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0029] A drum washing machine according to the present invention, as shown in FIG. 1, includes a water tub 11 located in a body 10, and a rotary drum 20 located in the water tub 11 to be rotated.

[0030] The water tub 11 is positioned to form an inclination of α degrees with respect to a surface on which the washing machine is mounted. The rotary drum 20 is positioned to be inclined in a same manner as the water tub 11. In detail, a front wall 22 of the rotary drum 20, in which an opening 23 is formed, is directed toward a position in front of and above the washing machine, with a rotation axis A of the rotary drum 20 mounted to form the α degree inclination with respect to the surface on which the washing machine is mounted.

[0031] A drum motor 13 is mounted on an outer surface of a back of the water tub 11 to rotate a rotating shaft 12 connected to the rotary drum 20. The rotary drum 20 may be rotated by an operation of the drum motor 13 in a single direction, or may be alternately rotated in opposite directions.

[0032] A body opening 14 is formed in the front of the body 10 to allow the laundry to be put into and taken out of the rotary drum 20. A door 15, which may be selectively opened and closed, is provided at the body opening 14 of the body 10. Additionally, cylindrically shaped bellows 16 are provided around the body opening 14 of the body 10 to prevent a water leakage.

[0033] A detergent container 18 to contain detergent, and a water supplier 30 to supply the wash water to be used in the washing process are provided above the water tub 11.

[0034] The water supplier 30 includes a first water supply pipe 32 designed to connect an outside water supply pipe 31 and the detergent container 18, a second water supply pipe 33 designed to connect the detergent container 18 and the water tub 11, and a first water supply valve 34 placed on the first water supply pipe 32 to control water supply. With this construction, wash water, supplied into the water tub 11, passes through the detergent container 18, so that the detergent contained in the detergent container 18 is supplied into the water tub 11, together with the wash water. The water supplier 30 further includes a third water supply pipe 35 branched off from the first water supply pipe 32, a second water supply valve 36 placed on the third water supply pipe 35, and a spray nozzle 37 located at an exit of the third water supply pipe 35 to supply the wash water into the rotary drum 20.

[0035] An electric heater 40 and a heater accommodating part 41, which accommodates the electric heater and contains the wash water, are provided in a lower portion of the water tub 11.

[0036] The drum washing machine of the present invention further includes a drain unit 50 to drain the wash water from the water tub 11, and a circulator 60 to supply wash water heated by the heater 40 from the water tub 11 into the rotary drum 20. The drain unit 50 includes a first drain pipe 51 connected to a drain outlet 42 formed in the heater accommodating part 41 to guide the wash water into the water tub 11, a pump motor 52 placed on the drain pipe 51, and a second drain pipe 53 connected to an exit side of the pump motor 52. The circulator 60 includes a drain valve 61 placed on the second drain pipe 53, a circulation pipe 62 extended from the drain valve 61 to the opening 23 of the rotary drum 20, and a spray nozzle 63 located at an exit of the circulation pipe 62 to supply the wash water into the rotary drum 20.

[0037] The drain valve 61 changes flow passages to allow the wash water to be drained from the exit of the pump motor 52 to an outside of the washing machine or to flow into the circulation pipe 62. The drain valve 61 may be a general electromotive three-way valve. This construction allows the wash water contained in the lower portion of the water tub 11 to be sprayed into the rotary drum 20 through the first drain pipe 51 and the circulation pipe 62 when the pump motor 52 is operated after the drain valve 61 is activated to allow the wash water to flow into the circulation pipe 62 (see FIG. 2B). In contrast, the construction allows the wash water to be

drained to an outside of the washing machine when the pump motor 52 is operated after the drain valve 61 is activated to allow the wash water to flow to the second drain pipe 53.

[0038] The rotary drum 20, as shown in FIGS. 3 and 4, includes a back wall 21 coupled to a rotary shaft 12, the front wall 22 having the opening 23 in a center portion thereof, and a cylindrically shaped sidewall 24 whose both ends are combined with the front wall 22 and the back wall 21, respectively.

[0039] In this case, the back wall 21 and the cylindrically shaped sidewall 24 form a closed space to fill the wash water. The sidewall 24 is formed so that an inner diameter thereof becomes larger in a direction from the back wall 21 to the front wall 22, and an inner surface thereof forms an inclination of β degrees with respect to the rotation axis A. A plurality of perforations 25 are formed along a radially outer portion of the front wall 22 of the rotary drum to allow the wash water to be drained therefrom when the rotary drum 20 is rotating at high speed. Additionally, a plurality of lifters 26 are arranged on the inner surface of the sidewall of the rotary drum 20 to raise and drop the laundry when the rotary drum 20 is rotating.

[0040] The laundry in the rotary drum 20 may be soaked with a small amount of wash water because the rotary drum 20 maintains the inclination of α degrees.

[0041] The inner surface of sidewall 24 of the rotary drum 20 maintains the inclination of β degrees and the front wall 22 of the rotary drum 20 is provided with the perforations 25 along the radially outer portion thereof, so that, when the rotary drum 20 is rotating at high speed, the wash water attempting to move in a radial direction by a centrifugal force flows into the perforations 25 of the front wall 22 formed along an inclined inner surface of the front wall 22 and drains from the rotary drum 20, as shown in FIG. 2A.

[0042] FIG. 5 is a block diagram of the drum washing machine of FIG. 1.

[0043] The present invention includes a controller 80 that controls overall operations of the drum washing machine. The controller includes a microcomputer 81 and a storage unit 83. The storage unit 83 stores information about set temperatures corresponding to a plurality of the washing courses. In this case, the set temperatures are applied to washing courses in which laundry is washed using wash water heated by the electric heater. The microcomputer 81

recognizes a set temperature corresponding to a washing course set by a user by searching the information stored in the storage unit.

[0044] An input terminal of the microcomputer 81 is connected to an input unit 85 to receive input commands set by the user, including an input command used to set a desired washing course, and a water temperature sensor 87 and a water level sensor 89, which are arranged at appropriate locations inside of the water tub to detect the temperature and level of the wash water contained in the water tub, respectively.

[0045] An output terminal of the microcomputer 81 is connected to a water supply valve drive unit 91 to drive the first and second valves 34 and 35, a drum motor drive unit 93 to drive the drum motor 13, a pump motor drive unit 95 to drive the pump motor 52, a drain valve drive unit 97 to drive the drain valve 61, and an electric heater drive unit 99 to drive the electric heater 40.

[0046] A method of controlling the drum washing machine according to the present invention is described with reference to the accompanying drawings below.

[0047] FIG. 6 is a flowchart showing the method of controlling the drum washing machine of FIG. 1. FIG. 7 is a graph showing variations of water temperature while the drum washing machine performs washing, which illustrates an example in which a washing course using the wash water heated by the electric heater is selected by a user from a plurality of washing courses.

[0048] Referring to FIG. 6, the user places the laundry into the rotary drum and selects a desired washing course from a plurality of the washing courses using the input unit 85 in operation 101. At this time, the user may set a desired temperature when the user desires to wash laundry using the wash water heated by the electric heater. However, even if the user does not input the desired water temperature and selects only the washing course, the microcomputer 81 may recognize a set temperature corresponding to the selected washing course by searching the information stored in the storage unit 83. For this purpose, the storage unit 83 must have stored information about set temperatures corresponding to a plurality of washing courses.

[0049] When the washing course is set, the microcomputer 81 activates the second supply valve 36 to open a flow passage so that only a small amount of wash water is supplied into the

rotary drum 20, and operates the drum motor 13 to rotate the rotary drum at low speed, thus performing a rough washing operation in operation 103. In this case, the rough washing operation is performed by rotating the rotary drum at low speed in a state in which a small amount of wash water has been supplied to the rotary drum to allow the laundry to be soaked with the wash water, thus causing preliminary washing and allowing main washing to be efficiently performed later.

[0050] The microcomputer 81 activates the first supply valve 34 to open the flow passage over a certain time so that flowing wash water may pass through the detergent container 18, thus putting the wash water and the detergent into the water tub, and operates the electric heater 40 to dissolve the detergent contained in the flowing wash water in the water tub in operation 105.

[0051] To reduce overall washing time, operation 105 is preferably, but not required to be performed together with operation 103. That is, the operations of supplying the wash water into the rotary drum 20 and putting the wash water and the detergent into the water tub 11 are performed simultaneously, and both the rotary drum 20 and the electric heater 40 are operated simultaneously.

[0052] The microcomputer 81 operates the drum motor to rotate the rotary drum 20 at high speed, thus draining the wash water contained in the rotary drum through the perforations 25 in operation 107. The drained wash water is mixed with the detergent solution contained in the lower portion of the water tub 11.

[0053] After draining the wash water 11 from the rotary drum 20, the microcomputer 81 detects the temperature of the detergent solution contained in the water tub 11 using the water temperature sensor 87, and determines whether the detected water temperature is equal to or higher than the set temperature corresponding to the selected washing course in operation 111. If, as a result of the determination, the detected water temperature is lower than the set temperature, the microcomputer 81 operates the electric heater 40 during a certain time to reheat the detergent solution contained in the water tub, thus increasing the temperature of the detergent solution in operation 113. As the detergent solution is heated by the electric heater 40 in the lower portion of the water tub 11, the temperature of the detergent solution increases gradually.

[0054] The microcomputer 81 operates the pump motor 52 and the drain valve 61 to allow the wash water to flow from the exit of the pump motor 52 to the circulation pipe 62, so that the reheated detergent solution is pumped by the pump motor and sprayed to the laundry in the rotary drum through the spray nozzle 63 in operation 117.

[0055] Subsequently, the microcomputer 81 operates the drum motor to perform a preliminary washing operation in which the laundry is washed over a certain time in operation 117, and the process then returns to operation 107. The preliminary washing operation is performed in stages until the detected water temperature reaches the set temperature (see FIG. 7). The reason why the preliminary washing operation is employed is that dirt and stains of the laundry are soaked with the wash water. For example, when a washing course to wash seriously soiled laundry is selected, the set temperature is set to a high value, so that a satisfactory washing effect is achieved by washing the laundry in stages using the detergent solution being gradually heated because the dirt and stains are soaked with the heated water solution.

[0056] If, as a result of the determination of the operation 111, the detected water temperature is equal to or higher than the set temperature corresponding to the set washing course, the microcomputer 81 performs the main washing operation in which the laundry is washed by operating the drum motor 13 in operation 119. The microcomputer 81 determines whether the main washing operation ends depending on whether a washing time counted by an internal counter reaches a washing end time in operation 121 while performing the main washing operation. If, as the result of the determination, the washing time is found not to have ended, the process returns to operation 119 to continue the main washing operation. If, as the result of the determination, the washing time is found to have ended, the microcomputer 81 finishes the main washing, and the process proceeds to operation 123 and performs set rinsing and spin-drying operations, thus terminating the selected washing course.

[0057] As described above, in the present invention, the operations of dissolving the detergent in the wash water in the water tub while performing the rough washing using a small amount of water supplied into the rotary drum may be performed at a same time, so that overall washing time is reduced, and efficient washing is performed because dry laundry is soaked with the wash water at an early stage.

[0058] The drum washing machine of the present invention performs the preliminary washing in which the wash water is drained from the rotary drum and then mixed with the detergent solution contained in the water tub and the wash water mixed with the detergent solution is reheated until a temperature of the wash water mixed with the detergent solution reaches a set temperature. Further, the drum washing machine of the present invention is provided with the structure in which the reheated wash water mixed with the detergent solution is sprayed and supplied into the rotary drum through the circulator. Accordingly, the drum washing machine of the present invention is capable of obtaining a satisfactory washing effect even though a relatively small amount of wash water is used. In particular, the preliminary washing operation is fit to remove dirt and stains from seriously soiled laundry.

[0059] Furthermore, the drum washing machine of the present invention is capable of reducing electric energy consumed by the electric heater because a relatively small amount of wash water is used.

[0060] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.